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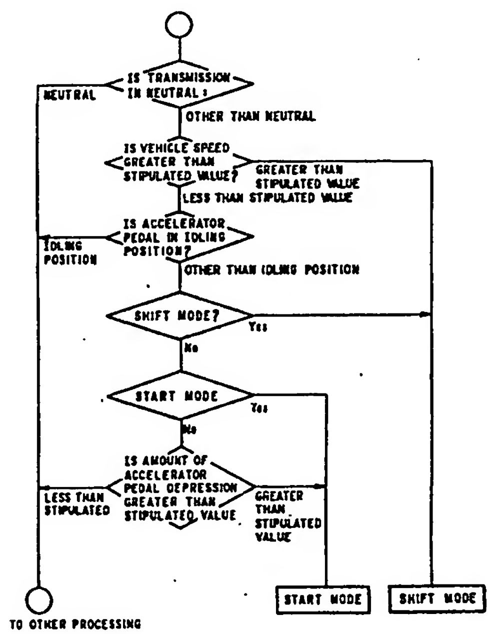
(54) Electronic control method for vehicles.

(57) When exercising control to start a vehicle from rest, the vehicle engine and a clutch are controlled in a very low speed control mode if the amount by which an accelerator pedal is depressed is less than a set value. If the amount of accelerator pedal depression is greater than the set value, the engine and clutch are controlled in an ordinary start control mode. When the vehicle is travelling and the speed thereof is less than a set value, the clutch is controlled in a start control mode. When the travelling speed of the vehicle is greater than the set value, the clutch is controlled in a shift mode.



ELECTRONIC CONTROL METHOD FOR VEHICLES

This invention relates to a control method for automatic vehicles and, more particularly, to a clutch and engine control method.

An automatic clutch known in the art automatically controls a friction clutch of an automobile, e.g., a dry-type single disk clutch, by means of an electronic control apparatus. Specifically, this type of automatic clutch automates the transmission and disengagement of motive power by a friction clutch by means of an electronic control apparatus which controls an actuator that operates in response to hydraulic, pneumatic or negative pressure. A control apparatus for an automatic clutch of this type is disclosed in the specification of Japanese Patent Publication No. 50-12648, wherein the engaged state of a clutch is gradually varied in dependence upon an increase in engine rpm, and in the specification of Japanese Patent Application Laid-Open No. 52-5117, where the rate at which a clutch is engaged is varied in accordance with engine rpm.

In a vehicle equipped with such an automatic clutch, operation is no different from that of a vehicle having an automatic transmission equipped with a torque converter. To propel the vehicle, therefore, the driver depresses the accelerator pedal a

considerable amount and continues to hold the pedal depressed until a certain velocity is attained. This is because of the operating characteristic of an automatic transmission equipped with a torque converter. More specifically, with an automatic transmission having a torque converter, the engine is constantly subjected to a load of a certain magnitude in the drive range. No matter how far the accelerator pedal is depressed, the engine will not race excessively. In addition, the higher the engine rpm and the greater the slip factor, the greater the torque ratio obtained. This increases the drive torque as well as the engine braking torque, thereby suppressing racing. In a vehicle equipped with the above-described automatic clutch, however, the clutch engaging operation is performed after a rise in engine rpm, which results in a number of inconveniences. First of all, when the clutch starts to be engaged, engine rpm rises considerably, during which time the vehicle itself is completely at rest. Therefore, (1) the engine races, (2) the amount of clutch slip sustained in a half-clutch operation becomes great owing to engine racing, thereby resulting in clutch wear and reduced clutch lifetime, and (3) fuel consumption rises as a result of (1) and (2). Secondly, after the driver depresses the accelerator pedal, a certain period of time is required before engine rpm rises. Since the clutch is controlled in accordance with the rise in engine rpm,

starting response is slow. Furthermore, since the vehicle will not move forward under these conditions even when the accelerator pedal is depressed, the driver tends to depress the pedal excessively. This not only aggravates the phenomena (1) through (3) but also increases the risk of sudden forward movement since the accelerator pedal will be in a considerably depressed state and the engine rpm high when the vehicle starts moving. In particular, problems are encountered when attempting to move the vehicle a slight amount at low speed, as when parking an automobile in a garage or close to a curb.

In the conventional clutch control system, a relevant proportional constant (constant of proportionality) may be set so that the clutch engaging operation takes place comparatively slowly in order to realize a smooth start and minimize both sudden forward movement and shock when movement starts. As a result of this setting of the proportional constant, however, clutch control is performed slowly in gear shifting following the starting of the vehicle, thereby lengthening the time for shifting and making it difficult to achieve smooth acceleration after the gear change. In addition, a shock is experienced when engine rpm undergoes a sudden change. When the proportional constant is set to a value suitable for gear shifting, on the other hand, problems in control are encountered when starting the vehicle from rest.

As regards engine fuel supply means, e.g, a

throttle valve in a gasoline engine or a fuel injection pump in a diesel engine, certain problems are encountered because such means are controlled independently of the clutch. Specifically, where the accelerator pedal is depressed to accelerate the vehicle from a state in which the clutch is disengaged when the vehicle is started or travelling at low speed, the clutch is controlled comparatively slowly to avoid shock and realize smooth acceleration, as explained above. As shown in Fig. 8, which is a characteristic curve showing degree of clutch engagement plotted against time, clutch engagement starts at time t_o and rises to 100% (full clutch engagement) at time t_1. A so-called "half-clutch" state prevails between times t_o and t_1. On the other hand, in, say, a gasoline engine, a throttle valve for controlling the amount of fuel and air supplied to the engine has its opening controlled, independently of the clutch, in accordance with the amount of accelerator pedal depression, to increase the fuel and air supply and raise the engine rpm.

Until the clutch becomes fully engaged, therefore, the engine races and the driver experiences an unpleasant sensation. At the same time, the engine rpm and the vehicle speed are not linearly related (1:1) until the clutch is fully engaged. This makes it very difficult for the driver to correctly operate the accelerator when starting the vehicle from rest. In addition, since the clutch is caused to slip while the engine is

rotating at high speed, drawbacks are encountered of increased fuel consumption and clutch wear.

An embodiment of the present invention can provide a control method for starting a vehicle, whereby engine racing is prevented when the vehicle is started from rest. Clutchwear and a decline in fuel economy, which accompany engine racing, during half-clutch operation, are reduced.

An Embodiment of the present invention can provide a control method for starting a vehicle, in which sudden forward movement of the vehicle is prevented by dividing clutch control at the time the vehicle is started from rest into a very low speed control mode and an ordinary starting mode selected depending upon the amount by which the accelerator pedal is depressed, so that the vehicle can be controlled with accuracy in cases where the vehicle is moved in small increments at very low speed, as when parking in a garage or close to a curb.

An embodiment of the present invention can also provide a clutch control method whereby clutch control is divided into a start mode and a shift mode depending upon the operating conditions of the vehicle, to achieve optimum control when starting the vehicle from rest and when changing gears.

An embodiment of the present invention can also provide a fuel control method capable of preventing

engine racing when a clutch is controlled.

According to the present invention, there is provided a method of controlling starting of a vehicle equipped with an accelerator pedal sensor for sensing an amount of depression of an accelerator pedal, a throttle actuator for controlling an amount of fuel supplied to an engine, an engine rotation sensor for sensing rpm of the engine, a clutch actuator for controlling an amount of engagement of a clutch, a clutch stroke sensor for sensing the amount of engagement of the clutch, and an electronic control apparatus which receives detection signals from each of the sensors for controlling the throttle actuator and the clutch actuator based on the detection signals. The method comprises steps of (a) sensing the amount of depression of the accelerator pedal, (b) performing a comparison to determine whether the amount of accelerator pedal depression is greater than or less than a set value, (c) selecting a start control mode depending upon the amount of accelerator pedal depression, and (d) controlling the throttle actuator and the clutch actuator in the control mode selected in the step (c).

According to another aspect of the present invention, there is provided a method of controlling a clutch in a vehicle equipped with an accelerator pedal sensor for sensing an amount of depression of an accelerator pedal, a clutch actuator for controlling an

amount of engagement of a clutch, a clutch stroke sensor for sensing the amount of engagement of the clutch, an engine rotation sensor for sensing rpm of the engine, a vehicle speed sensor for sensing travelling speed of the vehicle, a gear position sensor for sensing a gear position of a transmission, and an electronic control apparatus which receives detection signals from each of the sensors for controlling the clutch actuator based on the detection signals. The method comprises steps of (a) sensing the travelling speed of the vehicle, (b) performing a comparison to determine whether the travelling speed is greater than a set value, (c) selecting a clutch control mode depending upon the travelling speed of the vehicle, and (d) controlling the clutch actuator in the control mode selected in the step (c).

Reference is made, by way of example, to the accompanying drawings, in which :

Fig. 1 is a block diagram illustrating the construction of an engine and clutch control apparatus suitable for the application of embodiments of the present invention;

Fig. 2 is a flowchart illustrating how control is

performed in accordance with a vehicle starting control method according to an embodiment of the present invention;

Figs. 3(a) to 3(h) are graphs illustrating the control method indicated by the flowchart of Fig. 2;

Fig. 4 is a flowchart illustrating how control is performed in accordance with a clutch control method according to an embodiment of the present invention;

Fig. 5 is a block diagram illustrating the construction of an engine and clutch control apparatus according to another embodiment of the present invention;

Fig. 6 is a flowchart illustrating how control is performed in accordance with a fuel supply control method according to the present invention;

Figs. 7(a) to 7(c) are graphs useful in describing the control method indicated by the flowchart of Fig. 6; and

Fig. 8 is a graph indicating the amount of engagement of a clutch.

Fig. 1 shows a vehicle engine, clutch and a control apparatus for controlling the engine and clutch according to an embodiment of the present invention. An engine 2 is provided with a sensor 2a for sensing the rpm of the engine (e.g., engine shaft rotation speed). A throttle actuator 3

comprising a step motor or the like controls fuel supply means of the engine 1. A clutch 4 is provided for connecting and disconnecting motive force transmitted from the engine 2 to a transmission 5. A clutch actuator 6 for actuating the clutch 4 is equipped with a clutch position sensor 6a for sensing the amount of engagement of the clutch 4. A solenoid valve 7 is arranged in a hydraulic circuit of a hydraulic mechanism 8 for operating the clutch actuator 6 and comprises a hydraulic pump 8a and a reserve tank 8b. The solenoid valve 7 is adapted to control the hydraulic pressure acting upon the clutch actuator 6, thereby controlling also the speed at which the clutch actuator 6 operates. Numeral 9 denotes an accelerator pedal having an accelerator sensor 9a for sensing the amount of accelerator pedal operation. An electronic control apparatus 10 constituted by a microcomputer functions to control the clutch actuator 6 and throttle actuator 3 on the basis of output signals from the engine rotation sensor 2a, the clutch position sensor 6a, the accelerator pedal sensor 9a, a gear position sensor 5a for sensing the gear position of the transmission 5, and a vehicle speed sensor 53a.

In operation, the electronic control apparatus 10 receives an input from the accelerator pedal sensor 9a indicative of the amount of depression of the accelerator pedal 9, an input from the clutch position sensor 6a indicative of the amount of clutch

engagement, and an input from the engine rotation sensor 2a indicative of the rpm of engine 2. On the basis of these input signals, the electronic control apparatus 10 controls the solenoid valve 7 for operating the throttle actuator 3 and the clutch actuator 6, thereby controlling the fuel supply means and the clutch.

A control method according to an embodiment of the present invention will now be described in detail in conjunction with the flowchart of Fig. 2 and the several views of Fig. 3 illustrating how control is performed.

In step 1 of the flowchart, the electronic control apparatus 10 reads in and stores an amount of clutch engagement CLT from the clutch throttle sensor 6a. In steps 2, 3 and 4, the electronic control apparatus 10 reads in engine rpm ENG from the engine rotation sensor 2a, stores ENG in memory, finds the change in engine rpm and stores the change in memory. Next, in a step 5, the control apparatus 10 reads in an amount of accelerator pedal depression ACC from the accelerator sensor 9a and stores ACC in memory. The electronic control apparatus 10 then performs a comparison (step 6) to determine whether or not ACC is zero. If ACC is non-zero, the program moves to a step 7, in which the control apparatus 10 determines whether ACC is greater than a set value a for mode changeover. If it is determined here that ACC is less (not greater) than the set value a, then the electronic control apparatus 10

executes a step 8, in which a clutch control target position CLT:COM is set to a half-clutch range on the basis of previously stored map data shown in Fig. 3(a). Next, in a step 9, the electronic control apparatus varies the clutch operating speed CLT:SPD on the basis of previously stored map data shown in Fig. 3(b), with a position b at which the half-clutch region starts serving as a boundary. CLT:SPD is decided by the amount of clutch engagement. Then, until the set value a for mode changeover is reached, the electronic control apparatus 10 executes a step 10 to set a throttle target opening THR:COM, on the basis of previously stored map data shown in Fig. 3(c), so as to follow a curve corresponding to engine performance. Thus, control of the throttle opening is non-linear. The program then moves to a step 11, where the electronic control apparatus 10 performs a comparison operation to determine whether the amount of actual clutch engagement CLT, obtained from the clutch stroke sensor 6a, is less than the clutch control target position CLT:COM. If the result of the determination is affirmative, (CLT is less than CLT:COM), the program moves to a throttle control step (13). If the result is negative, then the clutch actuator 6 is operated at the clutch operating speed CLT:SPD. This is step 12 of the flowchart. This is followed by execution of a step 13, in which the electronic control apparatus 10 performs a comparison to determine whether the actual throttle

opening THR is equal to the throttle target opening THR:COM. If it is not, the control apparatus 10 executes a step 14 in which the magnitude of the actual throttle opening THR is compared with that of the throttle target opening THR:COM. If the actual throttle opening THR is greater than the throttle target opening THR:COM, then the throttle actuator 3 is moved toward the closing side (step 15). If THR is (not greater) ~~smaller~~ than THR:COM, the throttle actuator is moved toward the opening side (step 16).

If it is determined at Step 7 that the step 7 amount of depression of the accelerator pedal 1 is greater than the set value a for mode changeover, the electronic control apparatus 10 compares, in a step 17, the engine rpm ENG with a comparative engine rpm value obtained based on an amount of clutch engagement from previously stored map data shown in Fig. 3(d). If the engine rpm ENG is greater than the comparative value, the electronic control apparatus 10 executes a step 18. Here, based on previously stored map data illustrated in Fig. 3(e), the control apparatus finds a clutch operating speed CLT:SPD which exceeds the set value a for mode changeover owing to the amount of accelerator pedal depression ACC, controls the engaging speed of the clutch actuator in such a manner that the operating speed increases with the amount of accelerator pedal depression, finds, from previously stored map data shown in Fig. 3(f), a clutch

operating speed correction coefficient F6 for the amount of clutch engagement CLT, finds, from previously stored map data shown in Fig. 3(g), a clutch operating speed CLT:SPD correction term for a change in engine rpm ENG, and multiplies these together to correct the clutch operating speed CLT:SPD. If the engine rpm ENG is less than the engine rpm comparative value in accordance with Fig. 3(d), then the relation CLT = SPD is deemed to hold and the clutch is locked at the half-clutch position which prevails at that time (step 19). Next, in a step 20, the electronic control apparatus 10 finds an accelerator correction term for the amount of clutch engagement from the amount of accelerator depression ACC and previously stored map data shown in Fig. 3(h), thereby correcting the (value for the) amount of actual accelerator depression ACC to decide the throttle target opening THR:COM. This is followed by execution of step 11, in which the electronic control apparatus 10 performs a comparison to determine whether or not the amount of actual clutch engagement CLT is less than the clutch control target position CLT:COM, and this is followed by execution of steps among 12 to 16 as appropriate. The value of the amount of clutch engagement CLT and of the clutch control target position CLT:COM are large on the disengaged side and small on the engaged side.

Thus, a comparison is performed to determine whether the amount of depression of accelerator pedal 9 is greater or less (not greater) than the set value a. If it is

less, the clutch control target position CLT:COM is locked in the half-clutch range [Fig. 3(a)], and the clutch operating speed CLT:SPD is decided by the amount of clutch engagement [Fig. 3(b)]. The target opening THR:COM of the throttle, rather than being controlled linearly with respect to the amount of depression of the accelerator pedal 9, is regulated in such a manner as to follow a curve corresponding to engine performance [Fig. 3(c)].

If the amount of accelerator depression is greater than the set value, on the other hand, the engine rpm ENG and the engine rpm comparative value [Fig. 3(d)] with respect to the amount of clutch engagement CLT are compared. If the engine rpm ENG is greater than (or equal to) the comparative value, then the engaging speed of the clutch actuator is decided by the amount of accelerator depression ACC [Fig. 3(e)], the engaging speed of the clutch actuator is corrected in accordance with the amount of clutch engagement [Fig. 3(f)], and the engaging speed of the clutch actuator is corrected based on the change in engine rpm [Fig. 3(g)]. However, if the value of engine rpm is found to be less than the comparative value of engine rpm with respect to the amount of clutch engagement upon comparing the two, the engaging action of the clutch actuator is halted. This is followed by deciding the throttle opening from the amount of depression of the accelerator pedal 1 and from the amount of clutch

engagement [Fig. 3(h)].

Thus, the throttle is controlled independently of the amount of accelerator pedal depression until the clutch is fully engaged, and a changeover is effected between two control modes depending upon the amount of accelerator pedal depression. In other words, when the amount of accelerator pedal depression is less than a set value, a very low speed control mode is established in which the clutch control target position is locked in the half-clutch range, and in which the degree of half clutch and the throttle opening (and hence the amount of fuel supplied) are decided based on the amount of accelerator pedal depression. When the amount of accelerator pedal depression is greater than the set value, however, an ordinary start mode is established in which the clutch is fully engaged, the clutch actuation speed is decided based on the amount of accelerator pedal depression, and the throttle opening is decided based on the amount of accelerator depression and on the amount of clutch engagement.

Another method of clutch control according to the present invention will now be described with reference to Fig. 4.

In this embodiment of the present invention, vehicle speed is sensed. When the vehicle speed exceeds a prescribed value, a changeover is effected from a start mode to a shift mode to control the clutch in a different control mode. The control operation will now be described with reference to the flowchart of Fig. 4.

First, in a step 1, the electronic control apparatus 10 determines whether or not the gear position is the neutral position. If it is, the program shifts to another routine (other processing); if it is not, then the electronic control apparatus 10 executes a step 2 to determine whether or not the vehicle speed is greater than a set value. If it is, a shift mode is established in which an automatic clutch is subjected to control. If the vehicle speed is less than the set value, the electronic control apparatus executes a step 3 in which it is determined whether or not the accelerator pedal is in an idling position. If it is, the program moves to another routine (other processing). If the pedal is in a position other than the idling position, then the electronic control apparatus 10 executes a step 4. Here it is determined whether or not the shift mode prevails, namely whether or not the clutch is being engaged in the shift mode. If the decision is affirmative, the automatic clutch is maintained in the gear change (shift) mode; if negative, the program moves to a step 5. Here the electronic control apparatus 10 determines whether the start mode prevails. If the answer is YES, the automatic clutch is maintained in the start mode. A NO answer causes the program to move to a step 6, in which the electronic control apparatus 10 determines whether or not the amount of accelerator pedal depression is greater than a stipulated value. If it is, the start mode is established and the

automatic clutch is controlled accordingly; if it is not, the program moves to another routine.

This control method establishes a start mode and a shift mode by changing over the automatic clutch control mode in the manner described above. In each mode, the clutch can be controlled in a manner which will now be described.

First, in the start mode, the clutch engaging speed is controlled in accordance with the ordinary start mode (or possibly the very low speed control mode) of the above-described embodiment based on the amount of accelerator depression, the present clutch position and the change in engine rpm. However, if the engine rpm is low with respect to a value decided by the clutch position, clutch action is stopped. The relation for determining clutch speed (CLT:SPD) is expressed as follows :

CLT:SPD $\longleftarrow$

(1) 0 [providing that the condition $ENG < f_1$ (CLT) holds]

(2) f_8 (ACC) x f_8 (CLT) x f_4 (ENG) [providing that the condition $ENG \geq f_1$ (CLT) holds]

In the foregoing, ENG, CLT, ACC represent engine rpm, clutch position and amount of accelerator pedal depression, respectively, and f_1 (CLT) represents a function in which clutch position serves as a parameter. Similarly, f_2 ( ), f_8 ( ) and f_4 ( ) represent functions in which items enclosed by the

parentheses serve as parameters. Accordingly, when engine rpm becomes larger than the function f_1 in which clutch position is a parameter, the clutch speed is changed in dependence upon engine rpm and the amount of accelerator pedal depression, or the clutch speed is regulated in dependence upon the start of clutch engagement or a clutch position such as one close to full clutch engagement, whereby the clutch speed can be controlled so as to achieve a smooth start from rest. Further, with the engine running at high rpm owing to depression of the accelerator pedal, engine rpm will decline temporarily when the clutch is engaged, as is evident from the relation between f_2 and f_4. Owing to this temporary drop in engine rpm, clutch speed also declines and then rises as the engine rpm recovers, thereby making a smooth start possible.

Next, in the shift mode, clutch speed is controlled in dependence upon the amount of accelerator pedal depression, the gear in use and the clutch position. The relation deciding clutch speed (CLT:SPD) is expressed as follows:

$$\text{CLT:SPD} \longleftarrow$$

$$g\ (\text{ACC}) \times \text{stroke speed (CLUTCH)}$$

wherein g (ACC) is decided by the particular gear and represents a function in which the amount of accelerator pedal depression is a parameter. Accordingly, clutch speed is subject to control in dependence upon the amount of accelerator pedal

depression, thereby allowing rapid shifting of gears when the vehicle is travelling at high speed.

Another embodiment of the present invention will now be described.

Fig. 5 is a block diagram of an arrangement for practicing the present invention. Fig. 5 shows a vehicle engine, a clutch, a drive unit and a control apparatus therefor. An engine 2 includes fuel supply control means and has a flywheel 20. The fuel supply control means comprises a throttle valve for controlling the amount of fuel and intake air in the case of a gasoline engine, or a control lever of a fuel injection pump in the case of a diesel engine. An actuator 3 (hereafter referred to as a throttle actuator) drives the throttle valve or the control lever of the fuel injection pump and is equipped with a throttle opening sensor 3a. A clutch 4 comprises a well-known friction clutch and has a clutch release lever 41.

A clutch actuator 6 comprises a cylinder 61, a piston 62 slidably disposed within the cylinder 61, and a piston rod 63 having one end thereof connected to the piston 62 and the other end thereof engaging the clutch release lever 41. The clutch actuator 6 has a clutch position sensor 6a for sensing the positions to which the piston 62 and piston rod 63 are moved, namely for sensing the amount of engagement of clutch 2.

A hydraulic mechanism 8 constitutes a source of

fluid for such elements as the clutch actuator 6 and includes a hydraulic pump 8a disposed in a hydraulic circuit, a reserve tank 8b and an accumulator 8c. The hydraulic mechanism is in communication with a hydraulic chamber 61a of the clutch actuator 6.

Numerals 7a and 7b denote supply and discharge solenoid valves, respectively, disposed in the hydraulic circuit. Opening the supply solenoid valve 7a supplies the hydraulic chamber 61a of the clutch actuator 6 with pressured oil. Opening the discharge solenoid valve 7b discharges the pressured oil from the hydraulic chamber 61a. It should be noted that the discharge solenoid valve 7b is adapted so as to be pulse controlled.

A drive unit 50, which includes a transmission and a terminal deceleration device, has an input shaft 51 connected to the clutch 4, as well as left and right drive wheels 52, 53. Provided within the drive unit 50 is a transmission actuator which is controlled hydraulically.

A gear position sensor 5a senses the gear position of the transmission in the drive unit 50. Numeral 51a denotes a rotation sensor for sensing the rotational speed of the input shaft 51. A vehicle sensor 53a senses the rotational speed of a drive shaft 52 or 53. An engine rotation sensor 2a senses the rotational speed of the flywheel 20 provided on the engine 2.

The electronic control apparatus 10 is constituted

by a microcomputer and comprises a processor 10a for executing processing, a read-only memory (ROM) 10b storing a control program for controlling the clutch 6, the transmission of the drive unit 50, and the throttle actuator 3, an output port 10c, an input port 10d, a random-access memory (RAM) 10e for storing the results of processing, and an address data bus (BUS) 10f for interconnecting the foregoing components. The output port 10c of the electronic control apparatus 10 is connected, and delivers control signals to, the supply and discharge solenoid valves 7a, 7b of the clutch actuator 6, the actuator of the transmission in the drive unit 50, and the throttle actuator 3 of the engine 2. The input port 10d is connected to, and receives output signals from, the clutch position sensor 6a, the rotation sensor 51a, the vehicle speed sensor 53a, the engine rotation sensor 2a, the accelerator pedal sensor 9a (potentiometer) for sensing the amount by which the accelerator pedal 9 is operated, and a brake sensor 11a (potentiometer) for sensing the amount by which a brake pedal 11 is operated.

In operation, the transmission is controlled in the following manner. An output signal (detection pulse) SPS from the vehicle sensor 53a is periodically applied to the processor 10a via the input port 10d. The processor 10a responds by calculating the vehicle speed SPD and storing the calculated value in the RAM

10e. A signal indicative of an amount of accelerator depression ACC from the accelerator pedal sensor 9a is applied to the processor 10a via the input port 10d and is stored in the RAM 10e. The processor 10a obtains the gear position from a shift map stored as a portion of the program in the ROM 10b and corresponding to the vehicle speed SPD and the amount of accelerator pedal depression ACC, and applies a shift control signal TCS for the transmission to the transmission actuator via the output port 10c, and the transmission actuator is controlled accordingly. The transmission actuator is connected to the hydraulic mechanism 8 so that an internally located select-and-shift actuator is hydraulically controlled to actuate the transmission and synchronously engage the desired gear. During actuation of the transmission, clutch control is performed as described below to execute automatic shifting.

The clutch 4 is controlled when shifting, and when the vehicle is started and stopped. When shifting, the clutch 4 is disengaged prior to the shift. More specifically, the processor 10a delivers a clutch disengage signal CLC to the supply solenoid valve 7a via the output port 10c to open the valve. This causes the hydraulic chamber 61a of the clutch actuator 6 to be supplied with oil under pressure, whereby the piston 62 and piston rod 63 are moved to the left in Fig. 5. The piston rod 63 rotates the release lever 41

counter-clockwise about a support shaft 41a to disengage the clutch 4. Next, at the conclusion of the shifting operation, the processor 10a delivers a clutch disengage signal CLS to the discharge solenoid valve 7b through the output port 10c to open the valve. In consequence, the pressured oil is released from the hydraulic chamber 61a of the clutch actuator 6, and the piston rod 63 is gradually moved rightward to rotate the release lever 41 gradually in the clockwise direction about the support shaft 41a. The clutch 4 therefore makes a transition from the disengaged to the engaged state via the half-clutch state, as shown in Fig. 4. Since the amount of engagement CLT of the clutch 4 at this time corresponds to the position of the piston rod 6, the output signal CLTS of the position sensor 6a, which senses the position of the piston rod 63, has a magnitude corresponding to the amount of engagement CLT. Accordingly, the processor 10a is informed of the amount of engagement CLT of the clutch 4 by virtue of receiving the signal CLTS via the input port 10d, and stores the value of CLT in the RAM 10e. The clutch 4 is also disengaged when the vehicle speed drops below a prescribed value. That is, when the vehicle speed SPD, which is determined from the signal SPS produced by the vehicle speed sensor 53a, drops below a predetermined value, the processor 10a issues the clutch disengage signal CLC.

If the accelerator pedal 9 is depressed with the

clutch in the disengaged state when the vehicle is started or travelling at low speed, the electronic control apparatus 10 performs a control operation to engage the clutch. The electronic control apparatus 10 performs control by issuing the clutch engage signal CLS on the basis of a signal from the accelerator pedal sensor 9a indicating that the accelerator pedal 9 is starting to be depressed, or by controlling the opening of the throttle valve further. This will now be described with reference to the flowchart of Fig. 6.

The processor 10a of the electronic control apparatus 10 periodically reads the amount of depression AP of the accelerator pedal 9 from the accelerator pedal sensor 9a via the input port 9d and stores the value of AP in the RAM 9e (step 1). Next, in a step 2, the processor 10a reads the amount of engagement CLT of the clutch 4 from the position sensor 3b via the input port 9d and stores the value of CLT in the RAM 9e. Then, in a step 3, the processor 10a, on the basis of these detection signals, calculates a throttle valve opening signal THR, namely a fuel supply signal, in accordance with the following equation:

$$THR = AP \times CLT/100$$

wherein CLT ranges from 0 to 100.

Next, the processor 10a executes a step 4 for sensing the present throttle valve opening, namely fuel supply quantity, from the throttle valve opening sensor 3a via the input port 10d, and for comparing the value

of the sensed throttle valve opening with the signal THR indicative of the calculated valve opening. In a step 5, the processor 10a delivers a drive signal SVC to the throttle actuator 3 via the output port 10c. The drive signal SVC moves the throttle actuator 3 toward the closing side if the throttle opening is greater than signal THR, and toward the opening side if the throttle opening is less than the signal THR. If the throttle opening and the signal THR have identical values, then the processor 10a leaves the throttle actuator 3 as it is. Thus, the throttle valve is caused to act in either the opening or closing direction to control the engine rpm accordingly.

The above-described calculation is not performed when the clutch is in the engaged or disengaged state. Rather, the clutch is actuated when a request for moving the clutch from the disengaged to the engaged state is produced by the accelerator pedal 9 or by a drive position selection operation performed by a select lever, which is not shown. Thus, the amount of accelerator pedal depression serves directly as a throttle valve opening signal without there being any need to perform the foregoing calculation when the clutch is in the engaged or disengaged state. The result is quicker response. Of course, the calculation can be performed when the clutch is in the engaged or disengaged state, if this is preferred.

Throttle control executed in the manner described

above will gradually raise the engine rpm. That is, if the amount of depression of the accelerator pedal 9 changes as shown in Fig. 7(a) and the amount of clutch engagement changes as shown in Fig. 7(b), then, according to the present invention, engine rpm will rise gradually as shown by the curve a in Fig. 7(c) to eliminate the problem of engine racing that occurs in with the prior-art method, which is indicated by curve b in Fig. 7(c).

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

When exercising control to start a vehicle from rest, the vehicle engine and a clutch are controlled in a very low speed control mode if the amount by which an accelerator pedal is depressed is less than a set value. If the amount of accelerator pedal depression is greater than the set value, the engine and clutch are controlled in an ordinary start control mode. When the vehicle is travelling and the speed thereof is less than a set value, the clutch is controlled in a start control mode. When the travelling speed of the vehicle is greater than the set value, the clutch is controlled in a shift mode.

CLAIMS

1. A method of controlling starting of a vehicle equipped with an accelerator pedal sensor for sensing an amount of depression of an accelerator pedal, a throttle actuator for controlling an amount of fuel supplied to an engine, an engine rotation sensor for sensing rpm of the engine, a clutch actuator for controlling an amount of engagement of a clutch, a clutch stroke sensor for sensing the amount of engagement of the clutch, and an electronic control apparatus which receives detection signals from each of said sensors for controlling the throttle actuator and the clutch actuator based on the detection signals, said method comprising steps of:

(a) sensing the amount of depression of the accelerator pedal by the accelerator pedal sensor;

(b) performing a comparison to determine whether the amount of accelerator pedal depression is greater than or less than a set value;

(c) selecting a start control mode depending upon the amount of accelerator pedal depression; and

(d) controlling the throttle actuator and the clutch actuator in the control mode selected in said step (c).

2. A method according to claim 1, wherein the start control mode is a very low speed control mode when the amount of accelerator pedal depression is less than the set value, in which very low speed control mode a

clutch is controlled in a half-clutch range and the amount of clutch engagement and of fuel supplied are decided based on the amount of accelerator pedal depression, and the start control mode is an ordinary start mode when the amount of accelerator depression is greater than the set value, in which ordinary start mode the clutch is controlled until fully engaged, clutch operating speed is decided based on the amount of acccelerator pedal depression, and the amount of fuel supplied is decided based on the amount of accelerator pedal depression and the amount of clutch engagement.

3. A method according to claim 2, wherein the amount of clutch engagement and the amount of fuel supplied are uniquely decided by the amount of accelerator pedal depression.

4. A method according to claim 3, wherein an engagement operating speed of the clutch actuator is decided by the amount of clutch engagement.

5. A method according to claim 2, wherein an engagement operating speed of the clutch actuator is decided by the amount of accelerator pedal depression and corrected by the amount of clutch engagement and a change in engine rpm.

6. A method according to claim 2, wherein there is provided an ordinary start control mode in which engine rpm is compared with a comparative value of engine rpm obtained by calculation from the amount of clutch

engagement, and an engaging operation of the clutch actuator is halted when the engine rpm is less than the comparative value of engine rpm.

7. A method according to claim 2, wherein there is provided an ordinary start control mode in which the amount of fuel supplied is decided based on the amount of accelerator pedal depression and the amount of clutch engagement.

8. A method of controlling a clutch in a vehicle equipped with an accelerator pedal sensor for sensing an amount of depression of an accelerator pedal, a clutch actuator for controlling an amount of engagement of a clutch, a clutch stroke sensor for sensing the amount of engagement of the clutch, an engine rotation sensor for sensing rpm of the engine, a vehicle speed sensor for sensing travelling speed of the vehicle, a gear position sensor for sensing a gear position of a transmission, and an electronic control apparatus which receives detection signals from each of said sensors for controlling the clutch actuator based on the detection signals, said method comprising steps of:

(a) sensing the travelling speed of the vehicle by said vehicle speed sensor;

(b) performing a comparison to determine whether the travelling speed is greater than a set value;

(c) selecting a clutch control mode depending upon the travelling speed of the vehicle; and

(d) controlling the clutch actuator in the

control mode selected in said step (c).

9. A method according to claim 8, wherein the clutch control mode is a start control mode when the travelling speed of the vehicle is less than the set value, in which an engagement operating speed of a clutch is decided based on the amount of accelerator pedal depression, and a shift mode, in which an engagement operating speed of a clutch is based on the amount of accelerator pedal depression and a gear position, when the travelling speed of the vehicle is greater than the set value.

10. A method according to claim 9, wherein when the shift mode is already in effect, clutch control is performed in the shift mode even if the travelling speed of the vehicle is less than the set value.

11. A method of controlling supply of fuel to an engine in a vehicle equipped with an accelerator pedal sensor for sensing an amount of depression of an accelerator pedal, a throttle actuator for controlling an amount of fuel supplied to an engine, a throttle sensor for sensing the amount of fuel supplied, a clutch actuator for controlling an amount of engagement of a clutch, a clutch stroke sensor for sensing the amount of engagement of the clutch, and an electronic control apparatus which receives detection signals from each of said sensors for controlling the throttle actuator and the clutch actuator based on the detection signals, said method comprising steps of:

(a) sensing the amount of depression of the

accelerator pedal and the amount of engagement of the clutch ;

(b) calculating an amount of fuel to be supplied from the amount of accelerator pedal depression and the amount of clutch engagement ; and

(c) sensing an amount of fuel presently being supplied, comparing said amount with the amount of fuel supplied calculated in step (b), and controlling the throttle actuator in accordance with the result of the comparison.

12. Electronic control apparatus, for use in a vehicle, for carrying out a method as claimed in any preceding claim.

13. A vehicle having apparatus as claimed in claim 12.

Fig. 1

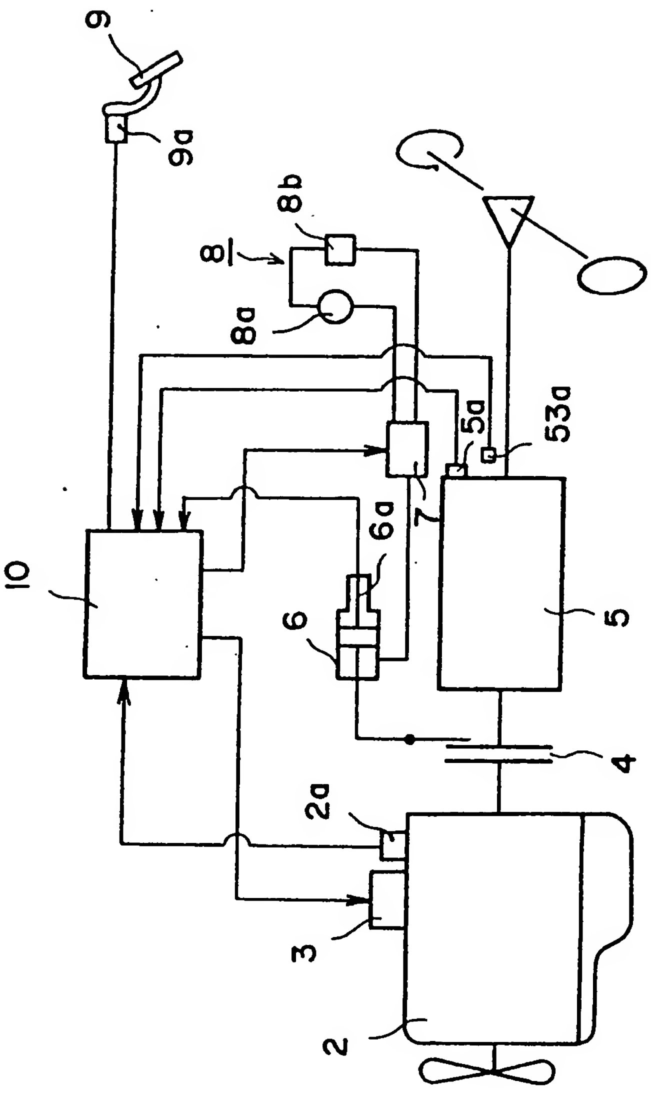


Fig. 2 0130794

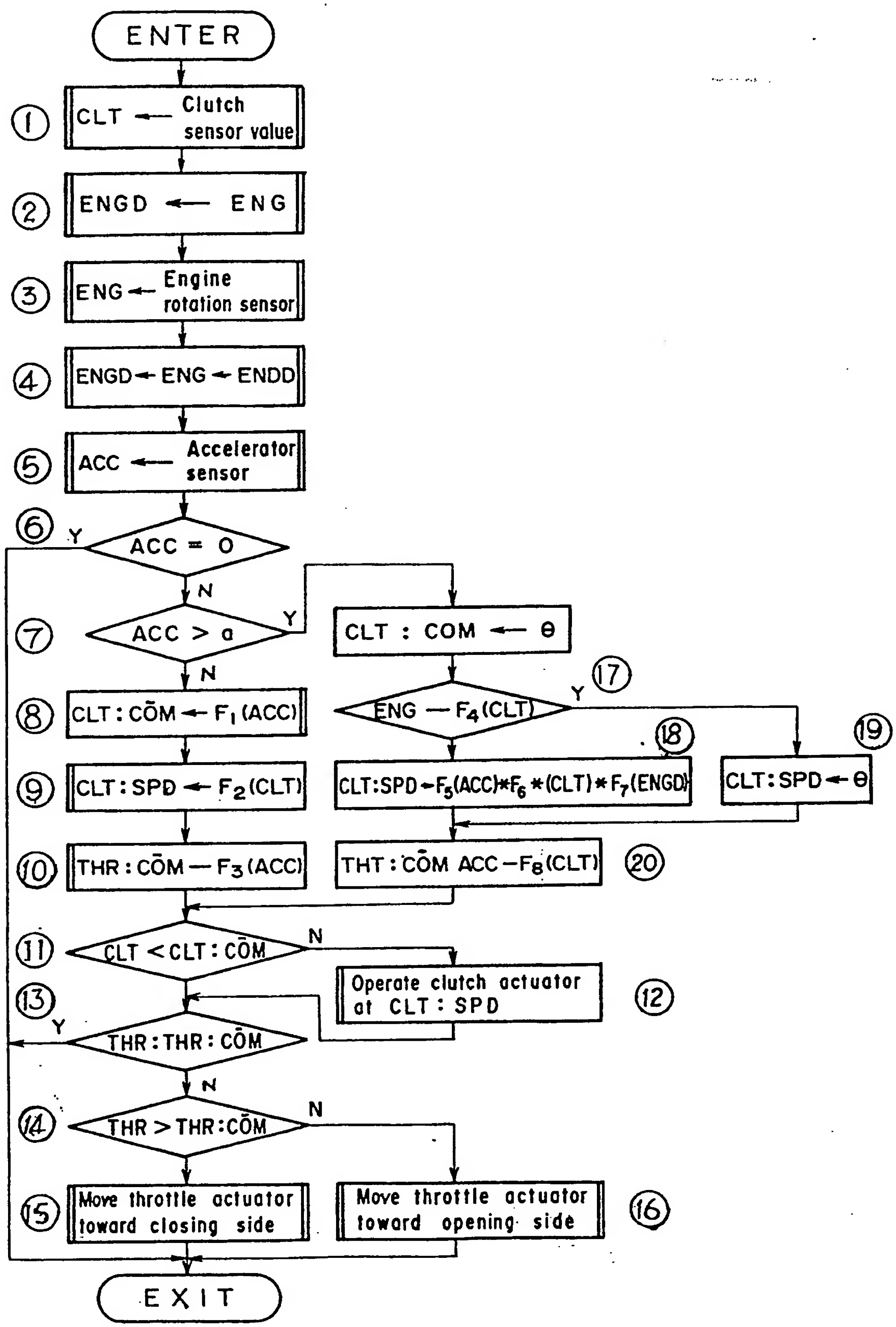


Fig. 3 (a)

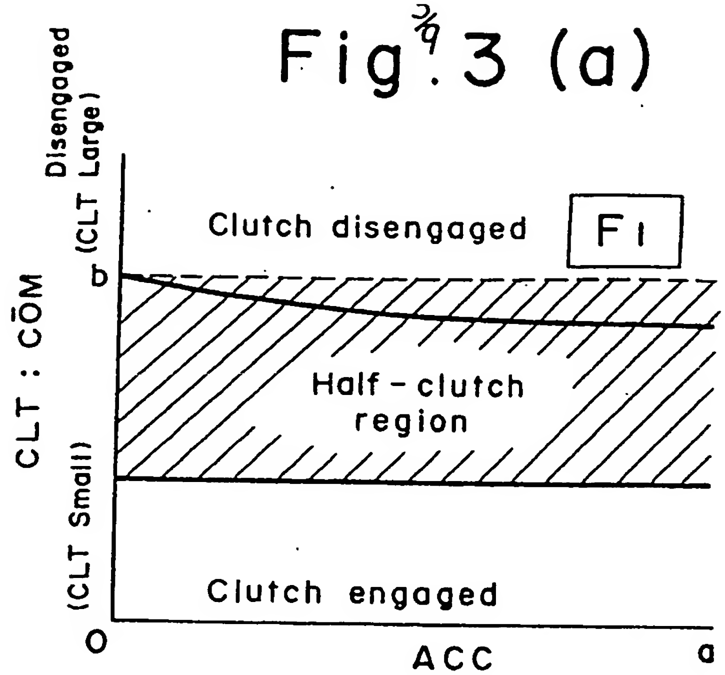


Fig. 3 (b)

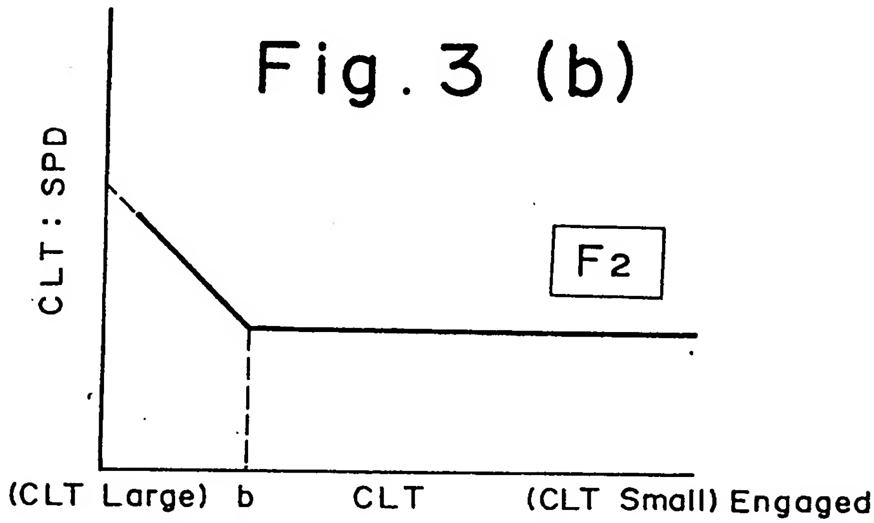


Fig. 3 (c)

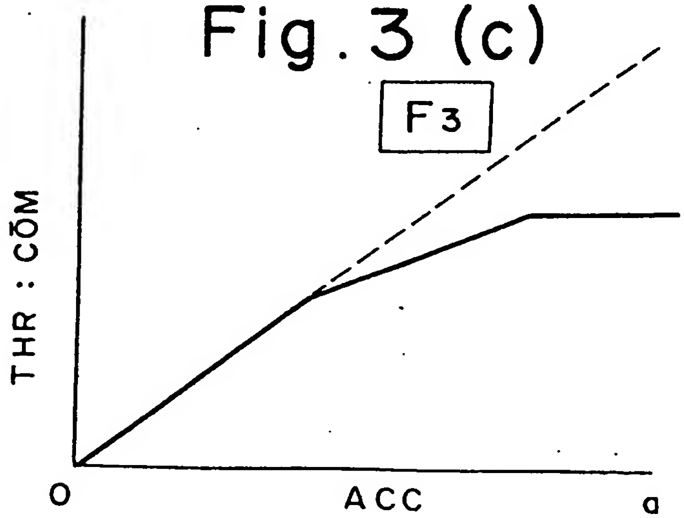


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Fig. 3 (d)

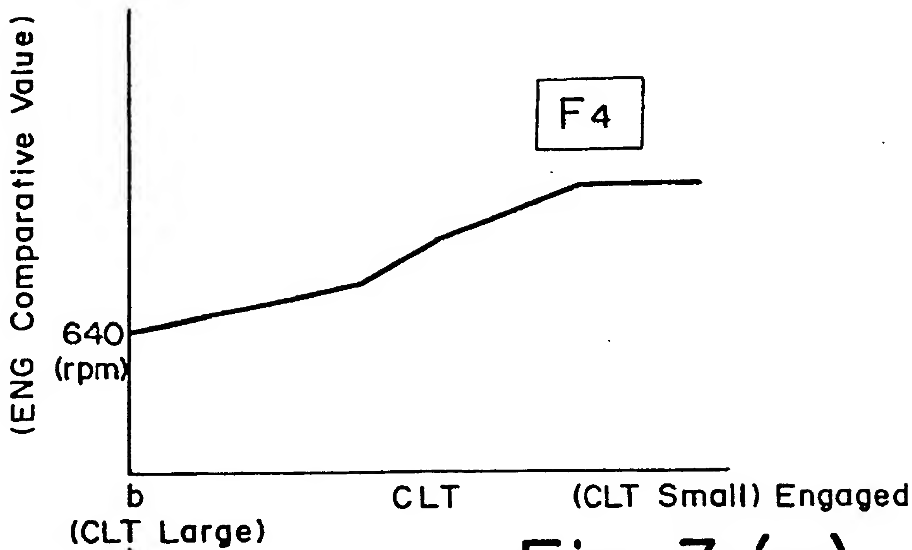


Fig. 3 (e)

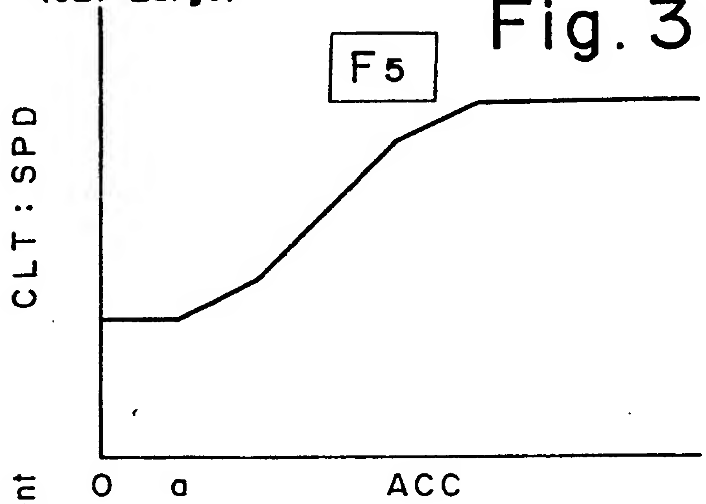


Fig. 3 (f)

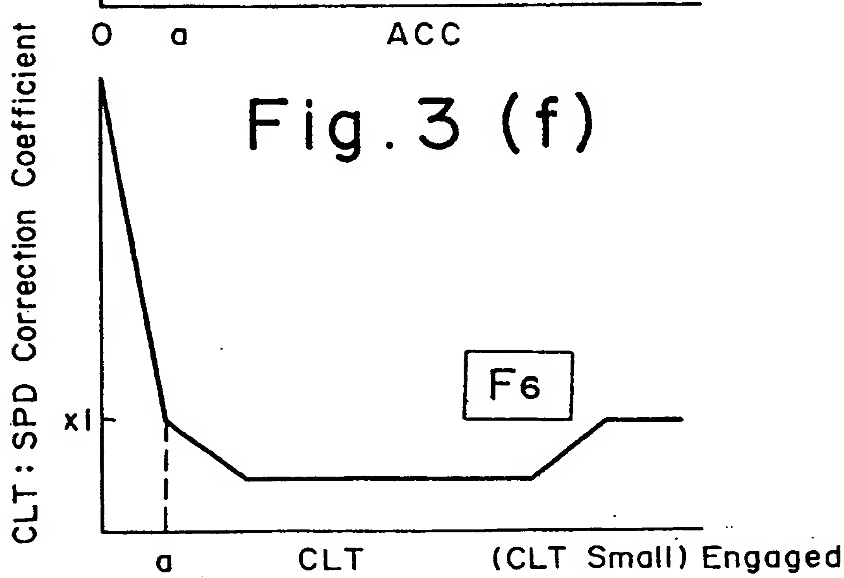


Fig. 3 (g)

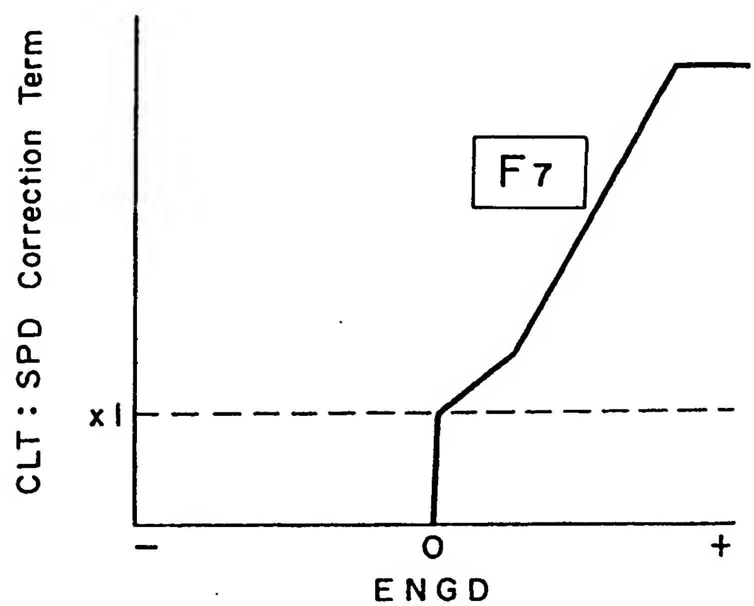

CLT : SPD Correction Term
x1
F7
−
0
+
ENGD

Fig. 3 (h)

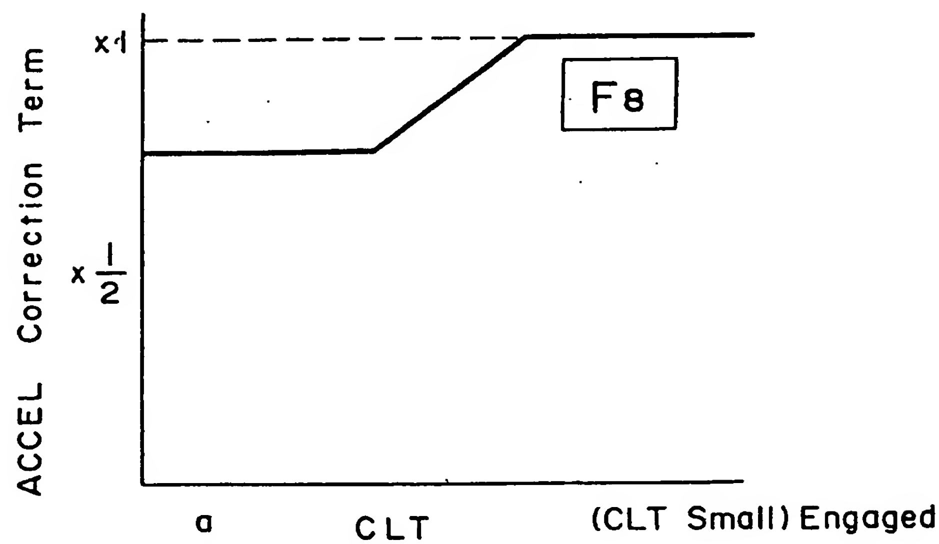

ACCEL Correction Term
x1
x 1/2
F8
a
CLT
(CLT Small) Engaged

Fig. 4

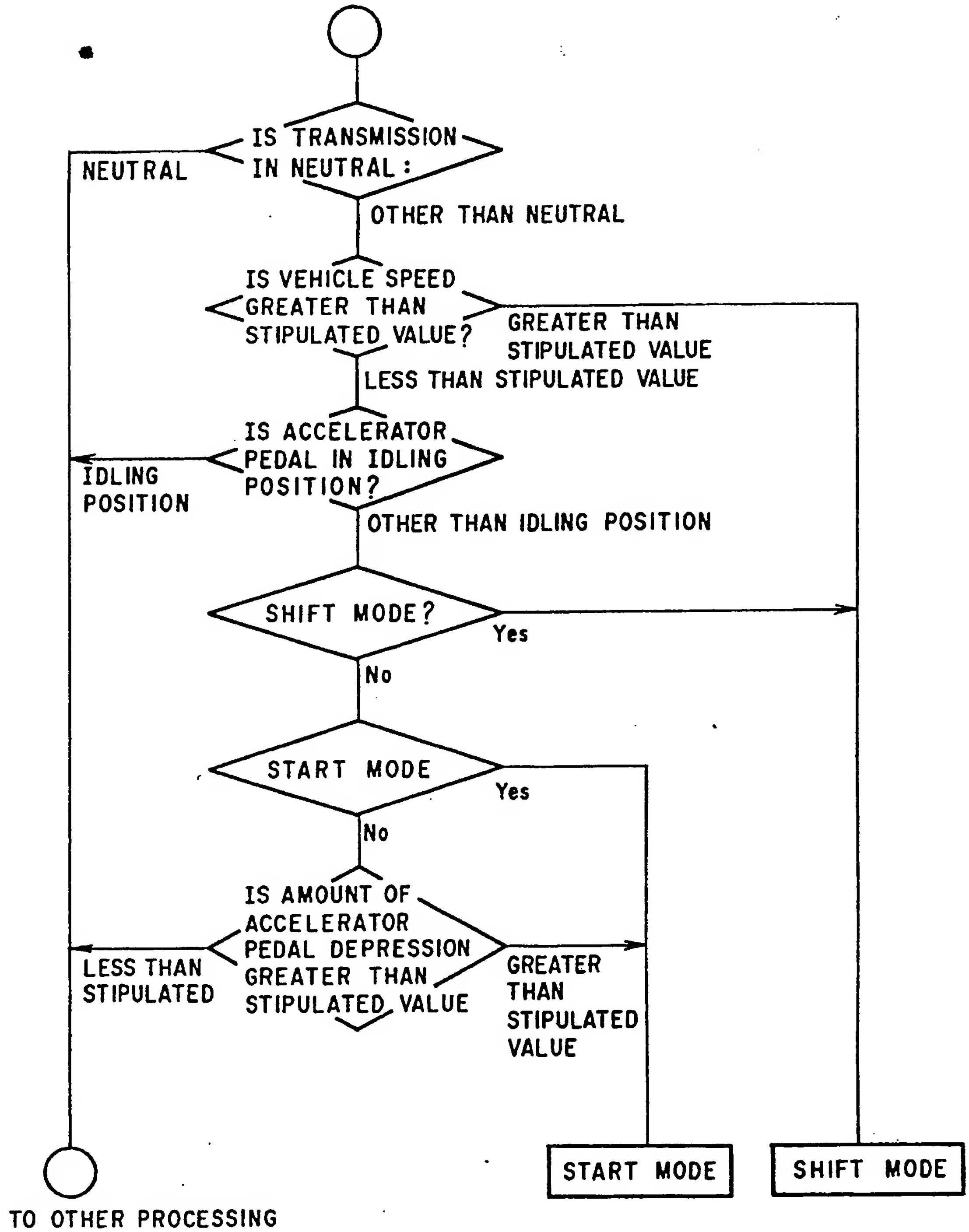

IS TRANSMISSION IN NEUTRAL :
NEUTRAL
OTHER THAN NEUTRAL
IS VEHICLE SPEED GREATER THAN STIPULATED VALUE?
GREATER THAN STIPULATED VALUE
LESS THAN STIPULATED VALUE
IS ACCELERATOR PEDAL IN IDLING POSITION?
IDLING POSITION
OTHER THAN IDLING POSITION
SHIFT MODE?
Yes
No
START MODE
Yes
No
IS AMOUNT OF ACCELERATOR PEDAL DEPRESSION GREATER THAN STIPULATED VALUE
LESS THAN STIPULATED
GREATER THAN STIPULATED VALUE
START MODE
SHIFT MODE
TO OTHER PROCESSING

Fig. 5

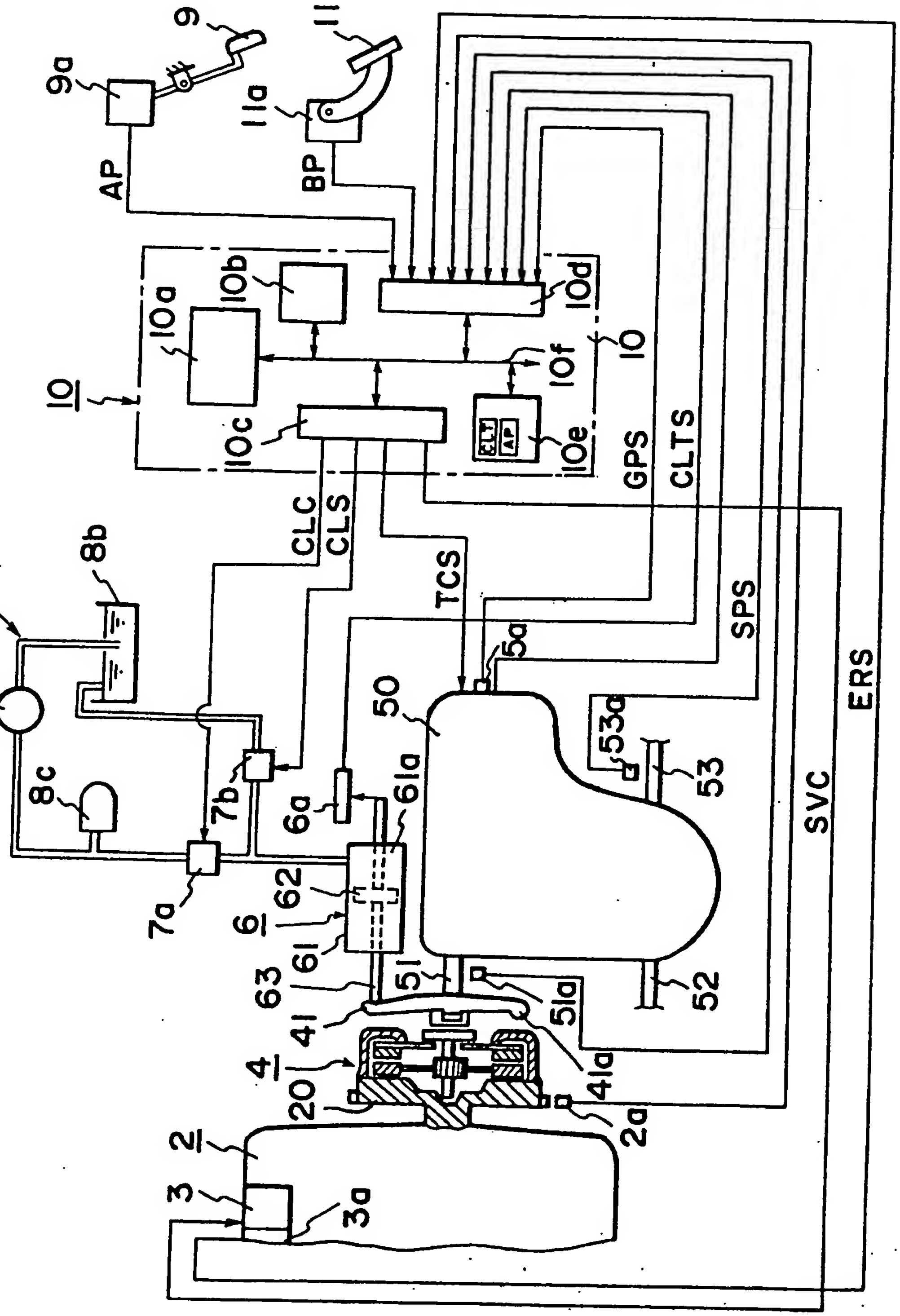

9
9a
11
11a
AP
BP
10
10a
10b
10c
10d
10e
10f
CLC
CLS
TCS
GPS
CLTS
SPS
SVC
ERS
8
8a
8b
8c
7a
7b
6
6a
61
61a
62
63
50
5a
51
51a
52
53
53a
4
41
41a
20
2
2a
3
3a

Fig. 8

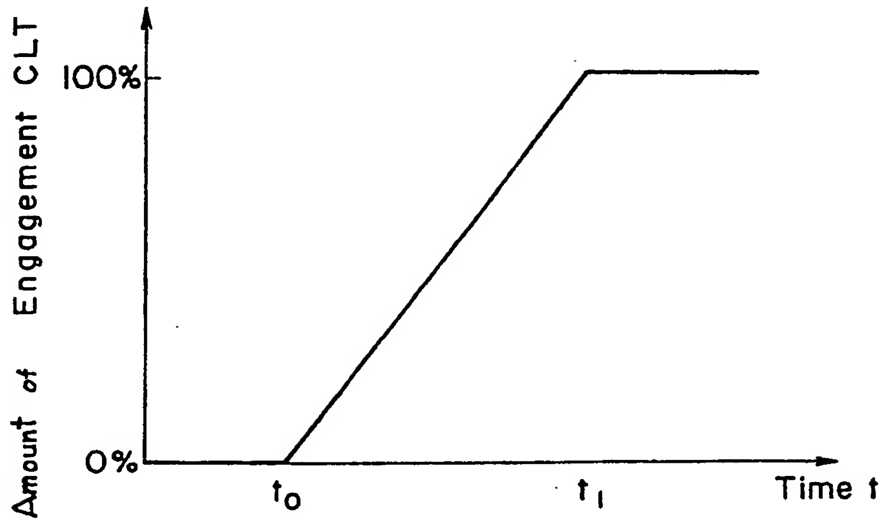

Amount of Engagement CLT
100%
0%
t_0
t_1
Time t

Fig. 6

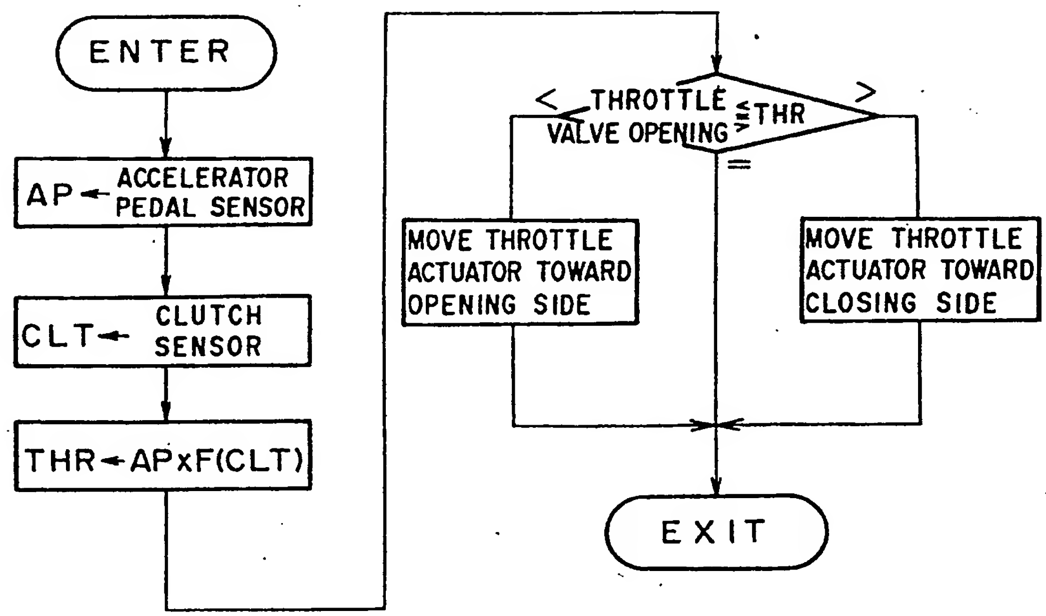

ENTER
AP ← ACCELERATOR PEDAL SENSOR
CLT ← CLUTCH SENSOR
THR ← APxF(CLT)
THROTTLE VALVE OPENING ≶ THR
<
>
=
MOVE THROTTLE ACTUATOR TOWARD OPENING SIDE
MOVE THROTTLE ACTUATOR TOWARD CLOSING SIDE
EXIT

Fig. 7 (a)

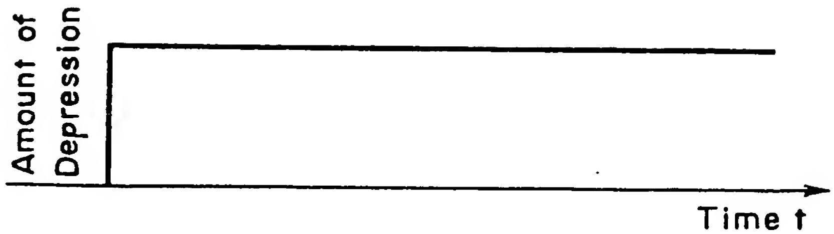


Fig. 7 (b)

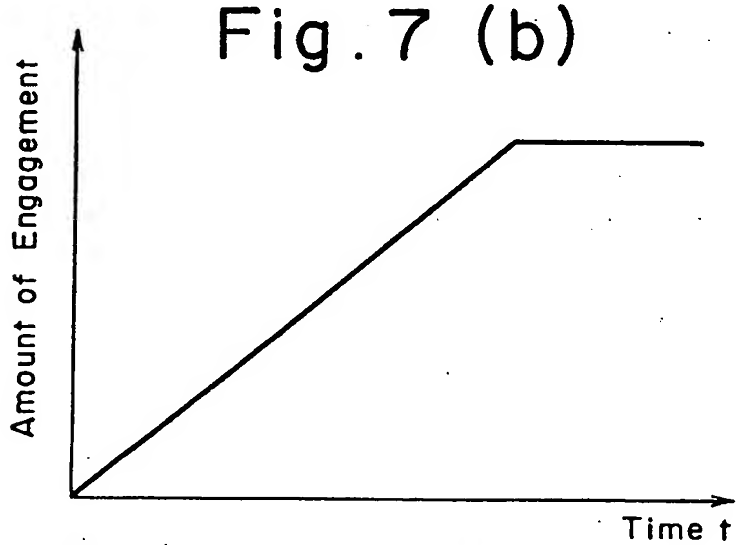
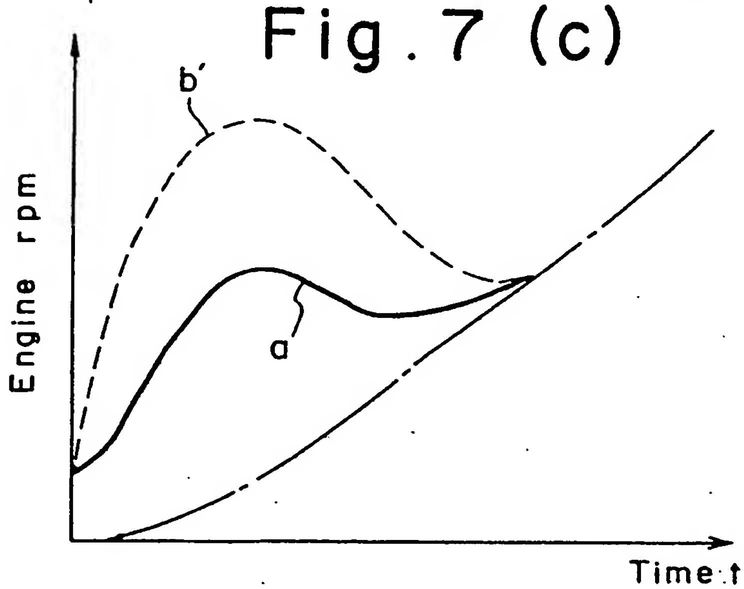


Fig. 7 (c)



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Application number

European Patent Office

EUROPEAN SEARCH REPORT

EP 84304380.3

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	EP - A2 - 0 038 113 (AUTOMOTIVE PRODUCTS LIMITED) * Fig. 1,2; claims; page 6, line 16 - page 7, line 18 * --	1	B 60 K 41/02
A	US - A - 4 331 226 (HEIDEMEYER et al.) * Fig. 1,1A; abstract; claims * --	1	
A	EP - A2 - 0 062 426 (AUTOMOTIVE PRODUCTS PUBLIC LIMITED COMPANY) * Fig. 1; claims; road speed sensor 1 * --	8	
A	DE - A1 - 3 028 250 (SACHS SYSTEM-TECHNIK GMBH) --		TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
A	DE - A1 - 3 145 630 (FUJI JUKOGYO K.K.) ----		B 60 K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	18-09-1984	DENK

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
L : document cited for other reasons
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